GPS EXPERIMENTS

N87-27599

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OVERVIEW:

Current funding of the FAA/TRI-U has been used for experimentation and exploration of the Global Positioning System (GPS). A method of collecting positional data has been devised using the FAA receiver built by Lincoln Labs which was originally designed for service as a long-term fixed monitoring station. Modification of the receiver continues and this will allow usage as an aircraft navigator.

Additional effort has been spent on development of an experimental receiver or test bed receiver that would allow modification and implementation of new GPS receiver design concepts. This receiver design is still in the concept stage, but is near completion and will stress low cost and application to the civilian aviation community. The receiver design will provide an ability to make design decisions and perform implementation in experiment form for proof of design.

The Lincoln Labs receiver will allow immediate ability to collect positional data while in flight. This ability allows a unique opportunity that will be immediately available to the center. Development of the test bed receiver will also allow for more flexible experimentation not currently available with the Lincoln Lab receiver.

PROBLEMS:

Problems with the Lincoln Lab receiver are being solved. This particular system requires excessive power and weight requirements not available in single engine aircraft. The Center has available a DC-3 aircraft that will more than meet the requirements of the Lincoln Lab receiver cargo. Some minor modifications and engineering tasks are being solved so the Lincoln Lab receiver can be installed in the DC-3 with minor modifications. Current status of the installation is being performed by this engineer with assistance of the aircraft's flight mechanic. Construction of the power wiring harness is complete, as are installation of the power inverters. Rack mounts are installed in the DC-3, and construction of the signal and control wiring harness is in progress. Several initial problems with the Lincoln Lab receiver have delayed installation, stemming from failed circuit traces on a three-layer processor board. These traces have been located and are being repaired with available tools. Assistance from Chuck Harris of STI has been invaluable with repair.

Most of the problems are related to the STI receiver component in the Lincoln Lab receiver, which was constructed as a prototype several years ago, and is starting to show age.

The goal of the test bed receiver design is to make it inexpensive and flexible. The current effort is directed toward developing a minimum cost Doppler tracking mechanism. This presents a problem because of the unique spread spectrum nature of the GPS code. A low-cost alternative to coded cross correlation is being investigated.

RESULTS:

Data collection for fixed position at two locations has been accomplished using the Lincoln Labs receiver. This enables troubleshooting and also data collection. A constant error in positional location regardless of location or time has been noted. This bias is probably due to an algorithmic problem in the receiver design. Modification of the receiver algorithm must take place. This will require expansion of the receiver management computer's memory capabilities. Plots of positional error from a known benchmark are shown. These are for three-dimensional error of Earth-centered position fix, as well as the individual components. The plots show six satellites, five satellites and finally a minimum of four satellites. As expected, the positional error with four satellites suffers from noise degradation due to geometric dilution of position (GDOP).

Receiver concepts are currently being proven with theoretical methods for performance comparison, as well as function. A final design proof is nearing completion. Implementation of this proof into hardware will provide the basis of a Doppler tracking device. Future pathways and possible developments will also arise with this component completion. Explanation of the basic code tracking concept is included in one of the following figures. Improvements for this design approach are currently being developed. The end result will be a flexible approach to codeless Doppler tracking. This will provide the core function of the test bed receiver. Added functions that can be developed will be intelligent loop control and tracking abilities, as well as implementation of navigation algorithms and conservation of loop resources.

CURRENT PROJECTS :

FAA RECEIVER FLIGHT

GPS DOPPLER TRACKING LOOPS

FAA RECEIVER FLIGHT

CONTINUED TROUBLE WITH THE STI RECEIVER .

- TRACKED TO AN INTERMITTENT TRACE ON THE CHANNEL 2 PROCESSOR CARD.
- TRACE NOT LOCATED YET DUE TO MULTILAYER.
- OBTAINED INFO AND PARTS FROM STI.

DC-3 POWER PANEL COMPLETE

- TESTED DUAL INVERTERS WITH NO LOAD.
- INSTALLED 28/120 VOLT WIRING OUTLETS AND PROTECTORS.
- INSTALLED METERING.

FAA RECEIVER FLIGHT

GROUND TESTS :

- OPERATED STI RECEIVER AT ALBANY LABS.
- COLLECTED FIXED POSITION DATA.

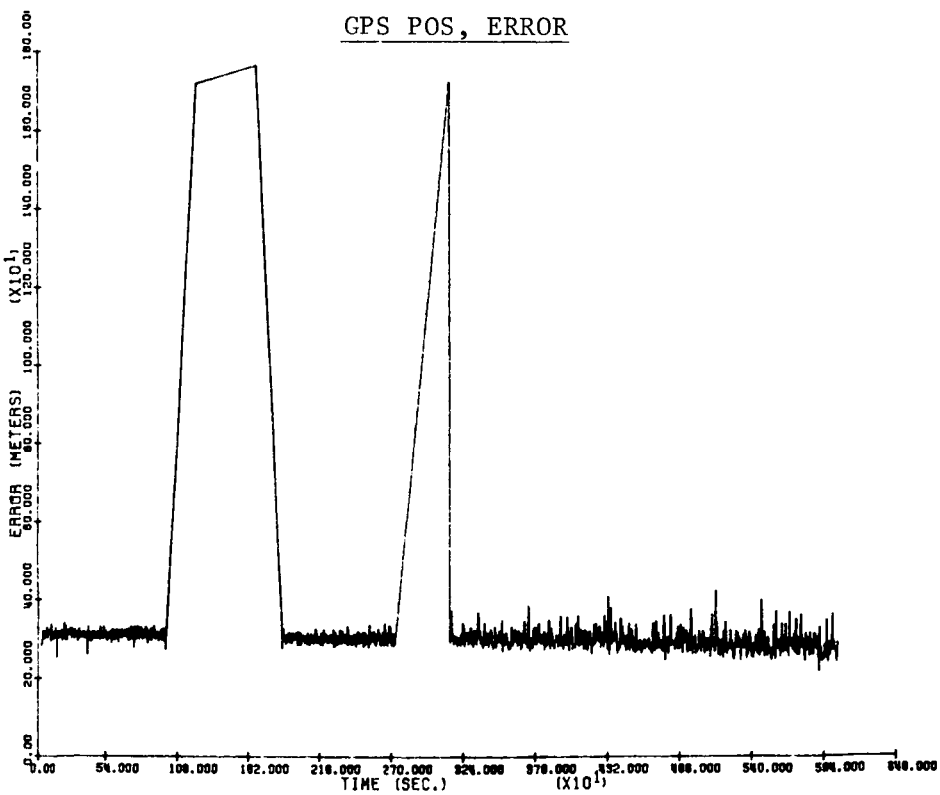
KNOWN BENCHMARK :

LATITUDE 39° 12' 39.803"

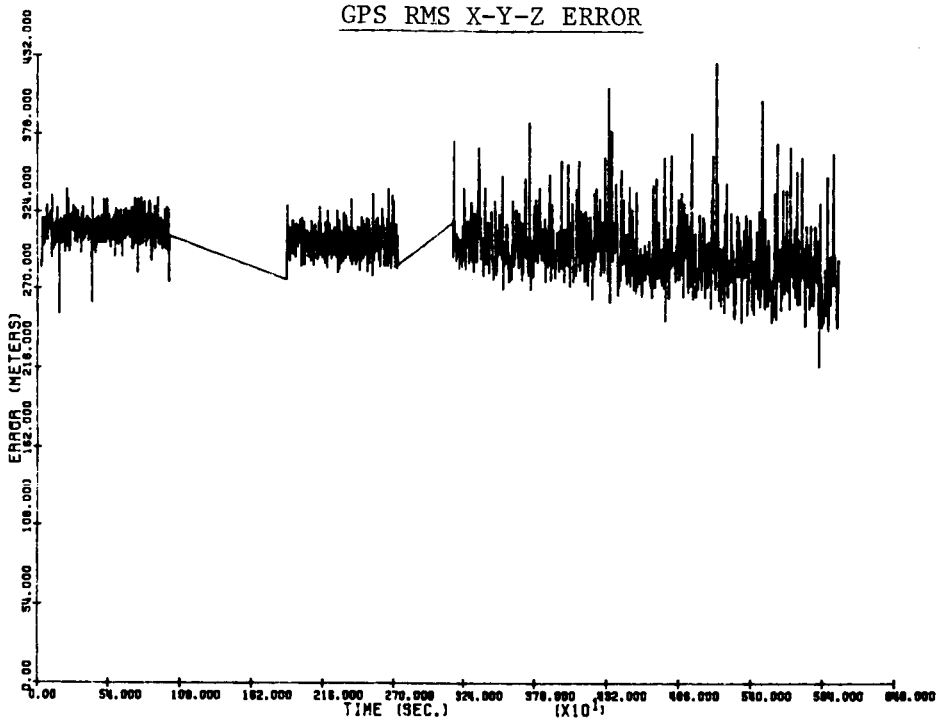
LONGITUDE -82° 13' 29.709"

ALTITUDE 196.06 Meters

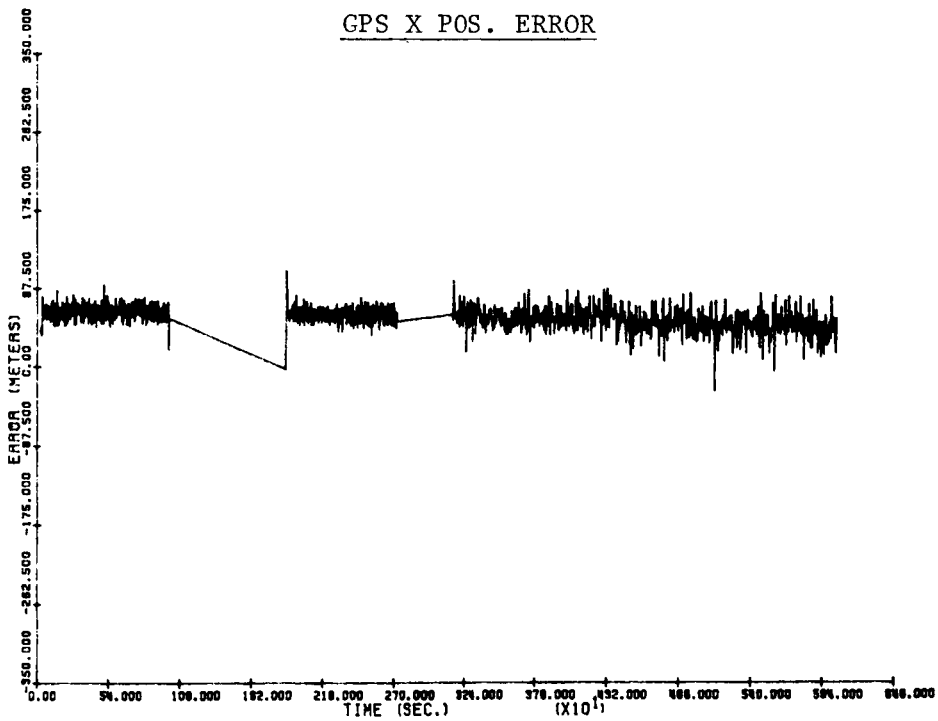
GPS POS, ERROR



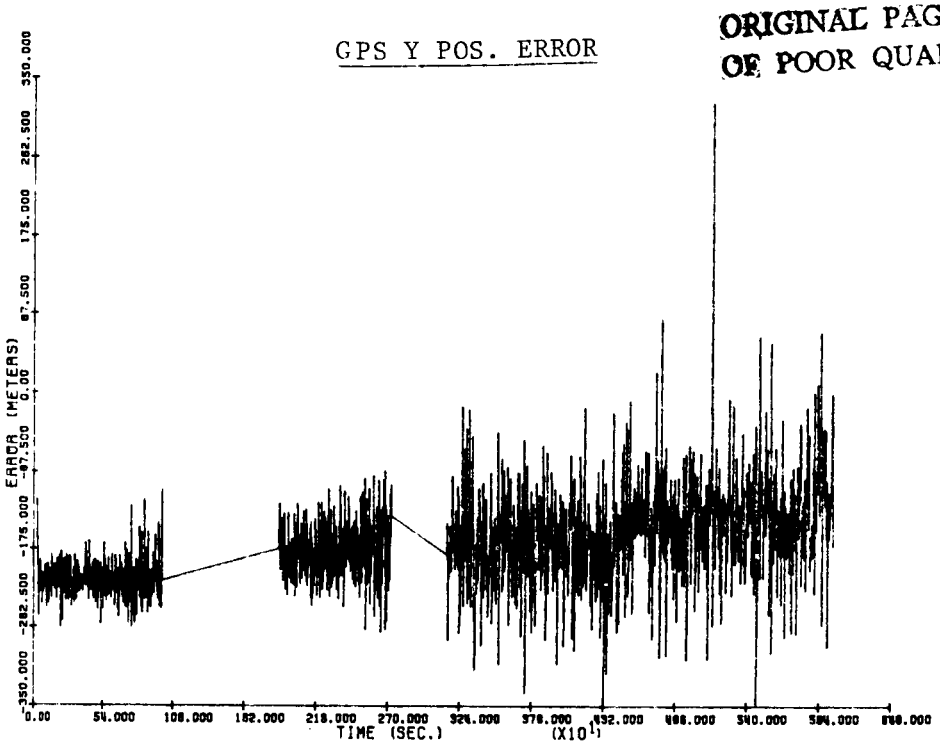
GPS RMS X-Y-Z ERROR



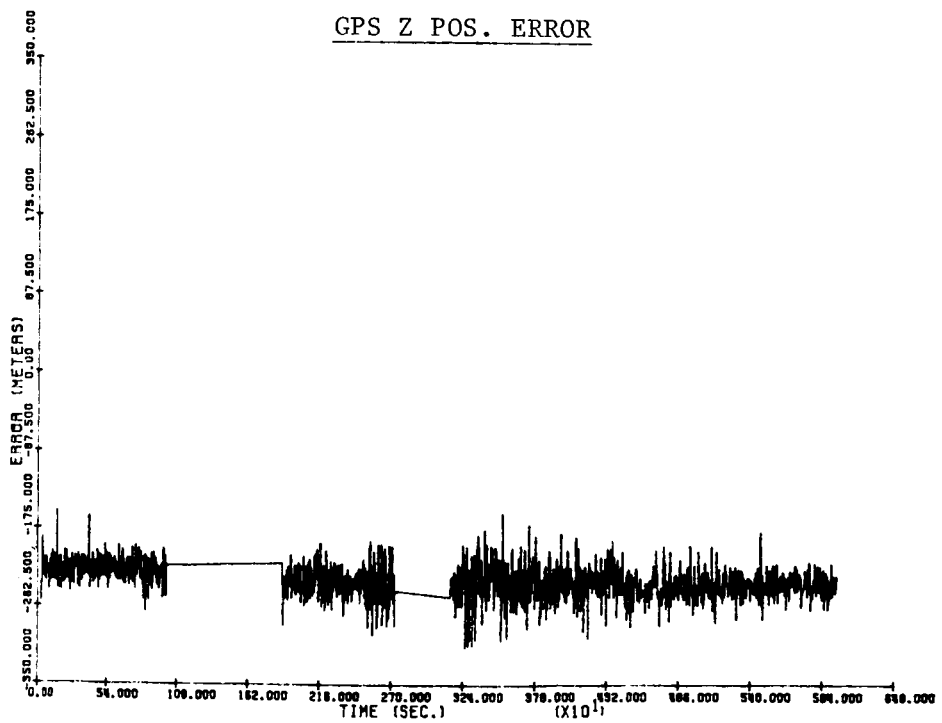
GPS X POS. ERROR



GPS Y POS. ERROR



GPS Z POS. ERROR



GPS DOPPLER TRACKING LOOPS

- ANALYSIS OF AUTOCORRELATION CONTINUES FOR SIMPLIFIED CASE.

- ANALYSIS OF DELAY LOCK LOOP CONTINUES FOR SIMPLIFIED CASE.

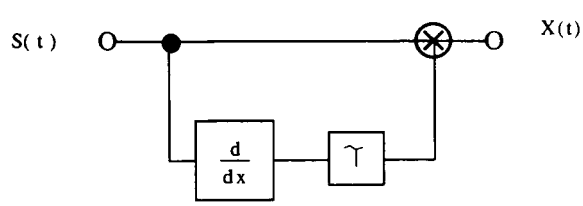
- COMPUTER SIMULATIONS OF ACTUAL C/A $\otimes$ D CODES.

ANALYSIS OF DELAY LOCK LOOP FOR 3-BIT CODE SEQUENCE

EXPRESSION FOUND :

$$X(t) = \sum_{N=2}^{\infty} \delta(t - N\tau)$$

FOR



INTEGRATING X(t) YIELDS CODE CLOCK REPLICA.